DOCUMENT RESUME

ED 138 618 95 TM 006 239

AUTHOR Lunneborg, Clifford E.
TITLE Information-Processing Correlates of the Raven Progressive Matrices Tests. 77-10.
INSTITUTION Washington Univ., Seattle. Educational Assessment Center.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.; National Inst. of Mental Health (DHEW), Rockville, Md.
PUB DATE Mar 77
NOTE 17p.; Paper presented at the Annual Meeting of the American Educational Research Association (61st, New York, New York, April 4-8, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Cognitive Processes; College Students; Correlation; *Intelligence Tests; *Nonverbal Tests; Verbal Tests
IDENTIFIERS *Ravens Progressive Matrices

ABSTRACT

Just as the Raven Progressive Matrices Test was uncorrelated in this sample with other measures of intelligence so was it much less well predicted from several information processing measures. It was found that verbal performance, indicated by a vocabulary score, was highly predictable from measures of information processing. While preserving order information was significant, it was the ability to overcome linguistic convention, in a right to left conversion task, that was the major determiner of verbal scores. Correlates of the Wechsler Adult Intelligence Scale (WAIS) verbal scores, partially dependent upon a vocabulary test, were essentially the same as those for the vocabulary measure itself. IQ's derived from the nonverbal subtests of the WAIS were well predicted by a pair of information processing measures that tap ability to maintain the order of input of nonverbal stimuli, either auditory or visual. Although Raven scores were not correlated with WAIS performance IQ's, these same two indices of accuracy of judgment on the temporal order of nonverbal stimuli also contributed to the prediction of the time required to solve Raven problems. Finally, there is the suggestion that verbal problem solving proficiency may be grounded in an ability to accurately maintain the order of speech elements. The two findings that at least some measures of nonverbal intelligence are linked to accuracy in recovering the order of nonverbal stimuli and that verbal problem solving efficiency is linked to accuracy in recovering the order of verbal stimuli, represent this study's contribution to the further development of relationships between psychometrically evaluated abilities and measures of information processing efficiency. (RC)

Documents acquired by ERIC include many informal unpublished materials not available from other sources. ERIC makes every effort to obtain the best copy available. Nevertheless, items of marginal reproducibility are often encountered and this affects the quality of the microfiche and hardcopy reproductions ERIC makes available via the ERIC Document Reproduction Service (EDRS). EDRS is not responsible for the quality of the original document. Reproductions supplied by EDRS are the best that can be made from the original.

ED138618

4.01

EAC REPORTS

EDUCATIONAL ASSESSMENT CENTER

University of Washington, 1400 Campus Parkway, PB-30, Seattle, Washington 98195 (206) 543-1170

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

Instructional Evaluation

Educational, Psychological, and Survey Research

Test Administration, Construction, Scoring, and Analysis

2

TM006 239

Educational Assessment Center

University of Washington

M 1977

77-10

Information-Processing Correlates of the Raven Progressive Matrices Tests

Clifford E. Lunneborg

Paper presented at the annual meeting of the American Educational Research Association, New York, April 1977, Research reported was supported jointly by grants to The University from the National Institute of Education (C. E. Lunneborg, Principal Investigator) and The National Institute of Mental Health (E. B. Hunt, Principal Investigator).

Educational Assessment Center Project: 262

Information-Processing Correlates of the Raven Progressive Matrices Test

Clifford E. Lunneborg

University of Washington

Among the techniques for assessing intellectual ability, at least in the English speaking world, a major emphasis has been the measuring of what has come to be termed verbal ability or verbal intelligence. Classically indexed by paper and pencil tests of vocabulary--tests of the recognition of synonyms or antonyms--this ability has been widely used as an indicator of academic promise. Indeed, such measures have been so taken as nearly synonymous with academic intelligence, at least, that the study of verbal ability seemed a natural place for us to start to look for relations between psychometric measures of cognitive abilities on the one hand and measures of information processing as they have been developed, theoretically and empirically, by modern cognitive psychology on the other. We found quite interesting relations and have since reported on the information processing characteristics of the "high verbal" (Hunt, Frost and Lunneborg, 1973, and Hunt, Lunneborg and Lewis 1975).

Verbal tests, of course, are not the only widely used assessments of intellectual ability. In particular, recent years have seen a growth of interest in measures which, at least on the face, would appear to be less culture-bound. One's vocabulary, after all ought to reflect on one's particular learning history

---

Paper presented at the annual meeting of the American Educational Research Association, New York, April 1977. Research reported was supported jointly by grants to The University from the National Institute of Education (C. E. Lunneborg, Principal Investigator) and The National Institute of Mental Health (E. B. Hunt, Principal Investigator).

as well as on one's "ability". Among the measures which have been proposed as less history-bound, less "crystallized" to make Cattell's distinction between crystallized (learned) and fluid (ability) intelligence, is the Raven Progressive Matrices test developed in Great Britain. The test involves non-verbal problems, figural reasoning problems of a kind not deliberately taught in schools. What information processing characteristics might be associated with those who do well at the Raven task? How might they differ from those characteristic of the "high verbal?" In one of our recent "marathon studies"--studies in which the same group of subjects participate in a large number of psychometric and laboratory assessments,--we had an occasion to begin to look at this question.

Method

Subjects

Sixty-three University of Washington freshmen (36 women and 27 men) were recruited fall 1974 from those who had completed the battery of tests administered high school juniors by the Washington Pre-College (WPC) Testing Program. These volunteers were selected so that the joint distribution of the WPC Verbal and Quantitative Composite scores in the sample reflected the distribution for the entire entering class. Participants were paid and served as subjects over an academic quarter.

Psychometric Measures

A vocabulary score (VOC) was calculated as the average of the high school administered WPC Vocabulary test, a test of recognition of synonyms, and of the Synonym-Antonym section of the Terman Test of Concept Mastery. The Terman Test was administered during the project and both sets of scores were standardized within the sample before averaging.

The Raven score resulted from the administration of Set II of the Advanced Progressive Matrices. Participants were given 50 minutes to respond to the 36 items, pacing their own performances. Score is the number of items answered correctly.

As an additional source of information about cognitive functioning, as viewed psychometrically, the Wechsler Adult Intelligence Scale (WAIS) was administered individually to members of the sample. Verbal, Performance and Full Scale IQs were established. The Raven was administered at the beginning of the project period and the WAIS at the conclusion of all other participation.

All of these measures of intelligence are, in some sense, measures of power. Because our earlier researches had focussed attention on speed of processing we decided to include, for the present analyses, some speeded indicators, among those intellectual measures. In the course of two laboratory tasks, response time measures were obtained and these will be treated here together with the psychometric measures of intelligence. Individually, participants were presented, one item at a time, Set I of the Advanced Progressive Matrices. This was done some weeks after group administration of Set II and involved 12 problems not in the larger set. Time to respond to each item--as well as choice of response--was recorded for each item. A principal components analysis of these data suggested that the time to respond to earlier and to later items in the series were separable. Two scores were used in this study: RAVEN TIME 1, the average of the standardized times to solve problems 1 and 2 and RAVEN TIME 2, the average of the standardized times to solve problems 8 and 9.

A second laboratory task called for learning a list of statements which associated each of a set of personal names either with occupations (Ruth is a lawyer) or locations (John is in the pool), or which associated locations with

activities (If you are in the park you can hear the chimes ring). A week later, following a recall test of mastery of these "facts", a series of True/False questions was presented. The questions were such as to require the retrieval of 1, 2, 3 or 4 of the "facts". Time to answer each question was recorded and two scores of interest derived. Verbal Problem Solving Slope (VERBAL SLOPE) and Verbal Problem Solving Intercept (VERBAL INTERCEPT) both resulted from linearly regressing the time to correctly respond to an item on the number of "facts" required by the item. These nine measures, including the Raven, are the "criteria" for the present study.

Information Processing Measures

As a first laboratory task, participants fixated a midpoint on a CRT display and responded by key press to the onset of a character to the left or right of that midpoint. In counter-balanced order students participated under two conditions. In the one-finger condition, the index finger of the preferred hand was used to depress one of two keys. In the two-finger condition keys under left or right index fingers were used to signal detection of stimuli to left or right respectively. Using median response times, separately for presentations to the left and right, for the first and last (sixth) blocks of 100 presentations under each condition, two principal components to these choice reaction times were identified. As a result, two composite measures were used in this study: CRT1 was the average of the standardized times to correctly respond for left and right presentations, first and last block under the one-finger condition. CRT2 was similarly defined for the two-finger condition.

In a visual temporal order judgement task students signalled by left or right hand key-press whether the first of two visual displays to a CRT screen appeared to the left or right of the screen. Onset asynchrony was counterbalanced

between the sides and was either 0, 15, 30, 45, or 60 milliseconds. Data treated here are based on the proportion of correct responses under the different conditions. LFIRST was the proportion of correct responses when the left stimulus led the right by either 30 or 45 milliseconds. RFIRST was identically defined for right stimulus led trials. VISUAL SLOPE and VISUAL INTERCEPT described the linear regression of proportion correct judgements on the stimulus onset asynchrony interval (averaging over right and left led trials).

In a dichotic listening task pairs of speech sounds (ba, da or ga) or pairs of non-speech sounds (buzz, hiss or tone) were presented separately to the left and right ears with one sound leading the other by 50 or 100 milliseconds. Participants were asked to identify which input occurred first and the number of correct responses recorded for each ear by lag condition. LNS and RNS were the number of correct responses to non-speech stimuli with the sound to the left or right ear leading, respectively. LSPCH and RSPCH were correspondingly derived from the speech sound trials.

Students also participated in a delayed auditory feedback task, reading aloud a page of what was English prose, the words having been randomly rearranged. Each participant read under three conditions; the reading was played-back through earphones with zero, 150 or 300 milliseconds delay. READ was the time taken to read the page with no delay in feedback. READEL was the average of the standardized times taken to read under the two delay conditions. ERSP and ERIN were counts of errors made in the reading under the delay conditions, the first a count of speech errors (stuttering, substituting a non-word for a word, etc.) and the latter a count of inversions, occasions on which word order was changed in the reading. (Counts of two other kinds of errors were

also made, though not included in this study. Number of words changed to other words loaded the same component as the number of speech errors in the analysis of measures collected in this task while the count of words omitted was not systematically related under the two delay conditions.)

Finally, during the delayed auditory feedback experimental session, participants were asked to read back aloud each of ten visually presented words substituting L's for R's and R's for L's in the reading. RTOL was the median conversion latency across the ten words.

Results

Table 1 reports the correlations of the information processing measures with the psychometric scores. The choice response times were not significantly correlated with any of the psychometric measures. Accuracy at the visual temporal order judgement task, notably when the leading stimulus is to the left visual field, correlated with WAIS performance IQ's and speed in responding to the RAVEN items. A similar pattern of correlations was obtained for LNS, the accuracy measure for those dichotic listening trials involving non-speech stimuli and for which the stimulus to the left ear led. RNS, accuracy in identifying those instances where a non-speech signal to the right ear preceded one to the left, correlated--in contrast--with the two verbal measures of intelligence (VOC and WAIS-V). Accuracy in distinguishing the order of speech sounds, right ear leading left ear (RSPCH), was the only measure with a significant correlation with the Raven score. When the speech signal was fed first to the left ear (LSPECH), accurate identification was related to quickness in the verbal problem solving task.

Table 1

Correlations Between Psychometric Measures and Performance on Information Processing Tasks

	VOC	RAVEN	WAIS-V	WAIS-P	WAIS-F	RTIME1	RTIME2	VERB S	VERB I
CRT1	10	-03	04	-22	-11	-07	-10	10	05
CRT2	-10	-07	10	-01	05	01	-21	-14	-25
LFIRST	25*	08	16	37**	30*	-35**	-47**	-10	02
RFIRST	03	11	-27	-14	-24	17	-05	-06	-12
VIS SLOPE	-02	-04	19	-29	-04	07	13	-10	09
VIS INTER	-08	-00	10	-01	04	00	00	04	-01
LNS	12	06	24	57**	47**	-15	-33**	-17	-04
RNS	43**	01	31*	22	33**	08	01	21	-10
READ	-44**	-07	-30*	-04	-23	-26	-26	09	28*
LSPCH	11	15	-05	13	04	09	02	-26*	-26*
RSPCH	15	33**	-16	06	-07	-01	-13	-13	-15
READEL	-31*	-02	-09	-13	-14	-27	-21	-13	36**
ERSP	-29*	-02	-24	-13	-23	-12	-09	-07	25*
ERIN	18	06	35	05	22	-25	-10	46**	12
RTOL	-54**	-21	-43**	-20	-40**	04	-02	02	12

Decimal points omitted. * $p \leq .05$ ** $p \leq .01$

Speed in reading through a stream of randomly ordered words, with or without the distraction of a delayed auditory feedback (READ and READEL), was related to better vocabulary performance as well as greater speed in responding to the verbal problems. Speech errors (ERSP) in the delayed auditory feedback task had these same high correlations, while inversion errors (ERIN) slowed the solution of verbal problems requiring the retrieval of larger numbers of facts. Finally, speed in accomplishing the R to L and L to R speech conversions was the strongest correlate of the two verbal intelligence measures.

There was fair consistency in the correlates of the verbal measures, then, and the two, as shown in Table 2, were well related to each other. The Raven, however, was not highly correlated with any of the other psychometric measures. The problem solving speeds, both for the Raven and Verbal problems, were related to WAIS scores, particulary to those contributing to the Performance IQ.

To attempt to gain further insight, those information processing measures which correlated significantly with the psychometric scores were employed as potential multiple predictors of those psychometric scores. The results of the multiple predictor selections are given in Table 3. While 36% of the vocabulary variability in this sample was associated with these predictors only 14% of the Raven score differences could be accounted for. This greater predictability of verbal comprehension replicates a finding of one of our earlier studies, (Lunneborg, 1977.)

Speed in the R to L conversion task and accuracy in detecting that a non-speech stimulis to the right ear preceded one to the left were the major determiners of verbal test performance. Accuracy when the non-speech stimulus occurred first on the left side and accuracy in identifying that a visual stimulus occurred first to the left side account for an appreciable amount of the variability in

Table 2

Correlations Among Psychometric Measures

	RAVEN	WAIS-V	WAIS-P	WAIS-F	RTIME1	RTIME2	VERB S	VERB I
VOC	26	62	01	41	-12	-04	28	-16
RAVEN		-26	-03	-19	-17	-02	-11	21
WAIS-V			41	88	-26	-22	-21	-55
WAIS-P				79	-48	-25	-43	-22
WAIS-F					-43	-29	-38	-51
RTIME1						54	17	-08
RTIME2							17	01
VERB S								-03
VERB I								

WAIS performance IQ's and speed in solving the more difficult Raven problems. Raven performance itself, however, could only be linked to accuracy in noting that of two speech stimuli, the one to the right ear was earlier in time. Relative resistance to distraction--reflected in relative resistance to the effect of delayed auditory feedback and superior accuracy in preserving the order of input of two speech signals when the first was heard in the left ear--contribute to speed in solving verbal problems involving retrieval of one to several learned facts. The two contributors to the prediction of WAIS full scale IQ's, LNS and RTOL, are those associated with the two WAIS components.

Discussion

This study, unfortunately, has taught us little about determiners of Raven performance. Just as the Raven was uncorrelated in this sample with other measures of intelligence so was it much less well predicted from the several information processing measures. On the other hand, we again found that the verbal performance investigated earlier, and exemplified here by the vocabulary score, was highly predictable from measures of information processing. While preserving order information, noted in our earlier reports, continued to be significant, it was the ability to overcome linguistic convention, in the R to L conversion task, that was here the major determiner of those verbal scores. Correlates of the WAIS-V scores, partially dependent upon a vocabulary test, were essentially the same as those for the vocabulary measure itself.

IQ's derived from the non-verbal or performance subtests of the WAIS, quite interestingly, were well predicted by a pair of information processing measures, LNS and LFIRST, that tap ability to maintain the order of input of non-verbal stimuli, either auditory or visual. Although Raven scores were not correlated

Table 3

Multiple Predictors of Psychometric Test Performance

Criterion	Predictor	R^2	Increment
VOC	RTOL	289	
	RNS	347	058
	LFIRST	362	015
RAVEN	RSPCH	110	
	RTOL	141	031
WAIS-V	RTOL	181	
	RNS	204	023
WAIS-P	LNS	329	
	LFIRST	356	027
WAIS-F	LNS	221	
	RTOL	336	115
RTIME1	LFIRST	124	
RTIME2	LFIRST	222	
	LNS	248	027
VERB INTER	READEL	128	
	LSPCH	171	042
VERB SLOPE	ERIN	207	
	LSPCH	217	010

Decimal points omitted

with WAIS-P IQ's, these same two indices of accuracy of judgement of the temporal order of non-verbal stimuli also contributed to the prediction of the time required to solve Raven problems. Finally, there is the suggestion that verbal problem solving proficiency (as distinct from the verbal comprehension ability measured by a vocabulary test) may be grounded in an ability to accurately maintain the order of speech elements. These two findings--that, at least some, measures of non-verbal intelligence or problem solving are linked to accuracy in recovering the order of non-verbal stimuli and that verbal problem solving efficiency is linked to accuracy in recovering the order of verbal stimuli--represent, we believe, this study's contribution to the further development of relationships between psychometrically evaluated abilities and measures of information processing efficiency. Both relationships offer testimony to the potential productivity of research in this area.

What may underlie the relatively poor showing of the Progressive Matrices test? Recent studies have suggested first that the Raven items may not be as homogeneous in their cognitive demands as was earlier supposed (Hunt, 1974) and second that there may be important differences between groups of respondents, as between men and women (Chiang and Atkinson, 1976), in the relations among information processing measures. Further understanding of the Matrices approach to intellectual assessment may depend, therefore, upon the successful clustering of items and/or of test-takers. We are working on both tasks at Washington now.

References

Chiang, A. and Atkinson, R. C. Individual differences and interrelationships among a select set of cognitive skills. Memory and Cognition, 4, 661-672, 1976.

Hunt, E. B. Quote the Raven? Nevermore! In L. Gregg (Ed.) Knowledge-Cognition, Hillsdale, N.J.: L. Erlbaum Assoc., 1974.

Hunt, E., Frost, N. and Lunneborg, C. Individual differences in cognition: A new approach to intelligence. In G. Bower (Ed.) Advances in learning and motivation, Vol. 7. New York: Academic Press, 1973.

Hunt, E., Lunneborg, C. and Lewis, J. What does it mean to be high verbal? Cognitive Psychology, 7, 194-227, 1975.

Lunneborg, C. E. Choice reaction time: What role in ability measurement? Applied Psychological Measurement, in press, 1977.